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Issued November 15, 1910.

United States Department of Agriculture,

BUREAU OF CHEMISTRY—Circular No. 62.

H. W. WILEY, Chief of Bureau.

A COMPARISON OF BEEF AND YEAST EXTRACTS OF KNOWN ORIGIN.

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INTRODUCTION.

Beef and other meat extracts of pasty consistency and various fluid preparations of animal origin are extensively sold in the United States, and while very few yeast extracts are manufactured in this country at present, they are made quite extensively in Germany and England. In judging of the quality of such products, the advantages to be derived from a knowledge of the composition of beef and yeast extracts prepared under known conditions are evident. The lack of such analyses in the literature of the subject has led to this study.

COMPOSITION OF LEAN BEEF AND OF YEAST.

The flesh of lean beef, according to analyses made in this laboratory, when calculated to a fat-free basis, consists approximately of 77 per cent of water, 1 per cent of ash, 19.70 per cent of protein, and 1.30 per cent of nitrogenous extractives, in addition to which 1 per cent of nonnitrogenous organic extractives are present. The analyses of the fresh samples naturally vary with the fat content. Approximately one-tenth of the total nitrogen is in the form of extractive or amino nitrogen. The total nitrogen averages 3.30 per cent and from 25 to 30 per cent of this is water soluble; 0.025 per cent of the nitrogen is calculated as ammonia nitrogen, using the magnesium oxid method. The content of kreatin averages 0.30 per cent and the acidity, calculated as lactic acid, 1 per cent. A large percentage of the phosphorus and one-half of the sulphur is water soluble. The nonnitrogenous organic extractives consist of glycogen, inosit, lactic acid, etc. When, in the commercial manufacture of meat extracts, the product is prepared from the liquor in which the meat for canning is cooked the coagulable and insoluble protein is largely removed. About 4 per cent of the beef consists of water-soluble protein, but a portion of this is removed as coagulable protein on heating and filtering. The amino bodies are water soluble; also the mineral matter, consisting largely of sodium and potassium phosphates. It is evident that all of the insoluble portions of the meat and some of the soluble substances are not utilized in the process of manufacturing the extract. The same is true to a more limited extent of yeast extracts.

The yeast used for extract manufacture has a varying water content, which averages 75 per cent. The organic matter consists of albumins, nucleoproteins, etc. The nucleoproteins are split during the manufacturing process into nucleic acid and protein, and the nucleic acid is further broken up into xanthin bases, pyrimidin bases, and phosphoric acid. Both varieties of extracts are generally considered to be valuable because of their flavoring and stimulating action rather than because they possess any marked food value. It is rather difficult to judge of the age of an extract, and Siegfried and Singewald [a] have suggested that this can be done by determining the relation of the total to the organic phosphorus, the organic phosphorus being highest in the fresh extract, where it comprises one-tenth of the total phosphoric acid.

DESCRIPTION OF SAMPLES.

The beef extracts, the analyses of which are here reported, were obtained from P. F. Trowbridge, of the Missouri Agricultural Experiment Station. They were prepared as follows: Five kilos of lean round beef were thoroughly ground and mixed, then extracted, washed with cold neutral water, and finally squeezed through cheese cloth. This process was repeated from eight to ten times, until the last washing gave no Biuret reaction. The filtrates were united, filtered, and concentrated on the water bath. The coagulum was removed by filtration several times and the evaporation continued until the extract became a semisolid mass, when it was placed in sample bottles for analysis. No preservative was added, the per cent of salts present being sufficient to prevent any decomposition of the sample. Mr. Trowbridge reports the condition of the animals from which the samples were obtained as follows:

A. P. 794. A grade Hereford one and one-half years old and thin; for six months had been held to a slow gain of one-half pound per day and at the time of slaughter was better than medium, but not fat enough for prime beef.

A. P. 795. An old bull, sample of round. from Swift & Co., Kansas City.

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[a] Zts. Nahr. Genussm., 1905, **10**: 521.

A. P. 796. A three and one-half year old grade Shorthorn, very thin. The animal had been kept on maintenance rations for six months and was thin at first.

A. P. 797. A yearling grade Hereford in medium condition, i. e., a condition for maximum growth without the laying on of fat.

The two yeast extracts examined were prepared in England from waste brewery yeast, the process of manufacture as observed by the writer being as follows: Exhausted brewery yeast was thoroughly washed in large vats with cold water to remove all of the beer and impurities and was then heated to produce a rupture of the yeast cells, after which it was evaporated in a vacuum cooker until the consistency of a paste was reached. At this point the water content was approximately 25 per cent. The extract in this consistency was forced through pipes into suitable containers before cooling. Sometimes these extracts were flavored with celery seed or other condiments. While extracts prepared in this manner have the same general appearance and odor as meat extracts, the color of the two extracts examined was somewhat lighter than that of a typical beef extract, and on careful comparison a difference in odor could be detected.

METHODS OF ANALYSIS.

The data reported in Table 1 were obtained as follows: The solids were determined by heating 2 grams of the extract in a platinum dish for ten hours at 70° C. in a vacuum of 26 inches. The samples were heated in an electric muffle at low redness to determine the ash and the chlorin was estimated by the Volhard[a] process. The phosphoric acid was estimated by the Neumann method[b] and the usual volumetric process. The organic phosphoric acid was determined according to Siegfried and Singewald.[c] The ether extract was determined by the official method. The insoluble nitrogen was not determined, as the solutions of the extracts were practically clear. The total nitrogen and the amino nitrogen were determined by T. C. Trescot, using the Kjeldahl-Gunning process.[d] The proteoses and peptones were separated from the amino bodies by the tannin salt method.[e] For purin bases the modified Schittenhelm method[f] was employed. The kreatin and kreatinin were estimated by the author's modification of the Benedict-Meyer method.[g] The acidity was titrated with tenth-normal sodium hydroxid, using a very dilute solution of the extracts and phenolphthalein as the indicator.

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[a] U. S. Dept. Agr., Bureau of Chemistry Bul. 107, Revised, p. 23.

[b] Zts. physiol. Chem., 1902 **37** : 115.

[c] Loc. cit.

[d] U. S. Dept. Agr., Bureau of Chemistry Bul. 107, Revised, p. 7.

[e] U. S. Dept. Agr., Bureau of Chemistry Bul. 99, p. 182.

[f] U. S. Dept. Agr., Bureau of Chemistry Bul. 114, p. 41.

[g] J. Amer. Chem. Soc., 1909, **31** : 692.

DISCUSSION OF ANALYTICAL DATA.

The samples, which were carefully stoppered and kept in an ice chest after arriving at the laboratory, were analyzed with the results reported in Table 1.

TABLE 1.—*Comparative analysis of beef and yeast extracts.*

ON BASIS OF ORIGINAL SAMPLE.

Determinations.	Yeast extract.		Beef extract.			
	A. P. 724.	A. P. 725.	A. P. 794.	A. P. 795.	A. P. 796.	A. P. 797.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Solids	73.73	72.34	84.78	86.23	79.73	86.66
Total ash	22.18	19.48	19.57	16.23	14.63	14.49
Chlorin of ash as sodium chlorid	2.38	1.72	1.67	2.07	2.05	1.83
Phosphoric acid:						
Of ash	2.71	2.76	2.30	2.63	1.96	2.22
Total	2.73	2.78	2.50	3.00	2.04	2.27
Organic	.24	.29	.25	.27	.20	.25
Ether extract	.83	1.01	6.33	7.85	6.34	6.95
Nitrogen:						
Total	5.40	5.31	9.43	9.43	8.63	9.13
Protease and peptone[a]	2.15	2.18	3.40	3.04	1.89	2.39
Amino	3.25	3.13	6.03	6.39	6.74	6.74
Purin base	.58	.64	....	.65	.77	.64
Kreatin	0	0	4.00	2.90	1.51	1.95
Kreatinin	0	0	2.22	2.60	2.35	2.62
Acidity[b]	9.86	10.27	11.23	10.54	10.14	12.33
CALCULATED TO A MOISTURE-FREE AND FAT-FREE BASIS.						
Total ash	30.42	27.32	24.94	20.71	19.93	18.18
Chlorin of ash as sodium chlorid	3.27	2.41	2.13	2.64	2.79	2.30
Phosphoric acid:						
Of ash	3.72	3.87	2.93	3.36	2.64	2.79
Total	3.74	3.89	3.19	3.83	2.78	2.85
Organic	.33	.41	.32	.35	.27	.31
Nitrogen:						
Total	7.41	7.45	12.02	12.03	11.76	11.46
Proteose and peptone[a]	2.95	3.06	4.33	3.88	2.58	3.00
Amino	4.46	4.39	7.70	8.15	9.16	8.46
Purin base	.80	.90	....	.83	1.05	.80
Kreatin	0	0	5.10	3.70	2.06	2.44
Kreatinin	0	0	2.83	3.32	3.20	3.28
Acidity[b]	13.52	14.40	14.31	13.45	13.82	15.47

[a] This figure includes about 25 per cent of the total kreatin and kreatinin nitrogen.
[b] Expressed as cubic centimeters of tenth-normal sodium hydroxid per gram.

The ash results are lower for the beef than for the yeast extracts with one exception, A. P. 794, giving practically the same figures as the yeast extract, A. P. 725. The chlorin content of the ash, calculated as sodium chlorid, is practically the same in the two kinds of extracts. The total phosphoric acid, that in the ash, and the organic phosphoric acid are also practically identical on the moist basis. The ether extract and all of the nitrogen figures for the beef extracts are considerably higher than those for the yeast preparations. The chief difference, which has been noted by many observers, is the absence of kreatin and kreatinin in the yeast extracts. While amounts of these two bodies present in the beef extracts are subject to considerable variation, depending on the per cent originally present in the flesh of the animals from which the individual extract was prepared, their absence in yeast extracts gives an excellent test for distinguishing between the two products. In the flesh of the beef all of the kreatin and kreatinin are present as kreatin, and a portion of this is changed to kreatinin by the long-continued evaporation in an acid medium to which the extracts are subjected.

Hehner[a] states that the kreatin and kreatinin content of meat extracts averaged from 10 to 11 per cent when a sufficient amount (25 cc) of picric acid was present. In the four samples of true beef extract reported in Table 1, when 25 cc of picric acid were used, the highest combined kreatin and kreatinin value obtained was about 8 per cent on the water-free and fat-free basis. The writer has never obtained a higher value than this.

The acidity figures, which were obtained by dissolving 1 gram of the extract in 300 cc of distilled water and titrating with tenth-normal sodium hydroxid, using phenolphthalein as the indicator, are practically the same for the two kinds of extracts.

All of these samples were tested for sugar by the copper reduction method, but none was found. On standing, a copper precipitate appeared. In the ether extract of the yeast extracts an amorphous residue was left in the fat flask approximating 1 per cent of the extract. The Salkowski reaction for cholesterol was applied to an aliquot of the ether-soluble residue dissolved in chloroform, but no reaction was obtained. In one or two samples of the beef extracts, especially A. P. 796, a large number of crystals was left in the fat flask. These crystals were more soluble in chloroform than was the yeast ether-soluble residue, but likewise gave no cholesterol reaction. Portions of both the meat and the yeast ether-extraction residues were tested for phosphoric acid with negative results.

The purin base results, obtained by the modified method of Schittenhelm[b] show that the beef and yeast extracts contain practically equal total amounts of these bases. Micko[c] has shown that adenin and guanin predominate in yeast extracts and hypoxanthin and xanthin in meat extracts. In a recent article Gamgee[d] states that the ingestion of yeast extracts involves an enormous increase of purin bases as compared with an ingestion of meat extracts. The figures he reports are, purin base nitrogen of yeast extracts 0.646 per cent, of meat extracts 0.433 per cent. Some recent figures reported by Chapman[e] show that the purin content of meat and yeast extracts are practically identical, and this agrees with the findings of the writer. There is no conclusive proof of Gamgee's claim that the purin bases of yeast extract are more injurious than those of meat preparations.

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[a] Pharm. J., 1907, **24**: 683.

[b] U. S. Dept. Agr., Bureau of Chemistry Bul. 114, p. 41.

[c] Zts. Nahr. Genussm., 1903, **6**: 781; 1904, **7**: 257; **8**: 225.

[d] Brit. Med. J., August 22, 1908, p. 449.

[e] Brit. Med. J., December 12, 1908, p. 1741.

The results reported in Table 1 have been calculated to a fat-free and water-free basis and these figures afford a far more accurate basis for determining the relative values of the two varieties of extracts. On the dry basis the ash of the two yeast extracts and also all of the phosphoric acid figures are higher than for the beef extracts. The total nitrogen and the amino or extractive nitrogen results are far below the beef-extract figures. The chlorin in the ash, the acidity, the proteose and peptone nitrogen, and the purin base nitrogen show no great variations in the different extracts examined. As the ash determinations were made by placing the sample in the cold muffle and gradually heating to low redness, there is a minimum loss of phosphoric acid, and it is probable that in many cases where the samples for ash are placed directly in a hot muffle a larger per cent of the phosphoric acid is volatilized. Emmett and Grindley[a] state that 23 per cent of the ash of beef consists of phosphorus. Some experiments made by the writer show that a large part of the phosphoric acid of beef and approximately one-half of the sulphur is soluble in water. The great solubility of the phosphoric acid of beef accounts, of course, for the large amount present in the extracts.

Lactic acid is a recognized constituent of beef extract. Gamgee[b] gives a method for its preparation from Liebig's meat extract. The writer found the characteristic zinc sarcolactate crystals described by Kühne in a sample of beef extract, but none was found in the yeast extracts. Salkowski[c] has recently found quite large amounts of inactive lactic acid in a commercial meat juice as magnesium crystals. He holds that the active lactic acid of meat is converted to the inactive form on standing.

The acidity of beef extract is due not only to the lactic acid of the beef, although this is the predominating acid, but also to the acid phosphates and proteins present. The nitrogen results on the water-free and fat-free basis show higher figures for the beef extracts examined than for the yeast preparations. The average figures show 11.82 per cent of total nitrogen in the former case and 7.44 per cent in the yeast extracts. The per cent of the amino bodies is much larger, both relatively and proportionally, than in the yeast preparations. The remainder of the nitrogen is present in both extracts as albumoses and peptones, which are valuable as food. The question of the presence of true peptones in these preparations is unsettled, though it is difficult to understand how albumoses and amino acids can both be present and no peptone. The dipeptid and polypeptid content of these products have not been investigated, and as the peptones and peptids are so closely related, if not identical, it seems justifiable to consider that peptones are present at least to a slight extent in beef extracts.

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[a] J. Amer. Chem. Soc., 1906, **28**: 56.

[b] Physiol. Chem., 1880, **1**: 361.

[c] Zts. physiol. Chem., 1909, **63**: 237.

SUMMARY.

(1) The yeast extracts contain approximately 1 per cent of ether-soluble material, the beef extracts larger amounts. No cholesterol was found in the ether extracts. Sarcolactic acid was found in the beef extracts examined, but not in the yeast samples.

(2) The phosphorus of beef is largely water-soluble, consequently a considerable per cent of the ash of beef extracts is composed of this constituent. Approximately one-half of the sulphur of beef is water-soluble. Yeast extracts derived from yeast rich in phosphorus also contain a large amount in the ash. The total amount present is larger than the ash content, showing that some phosphoric acid is volatilized on ashing. The organic phosphorus determined by the Siegfried-Singewald method gives approximately the 1:10 ratio compared with the total as suggested by those authors.

(3) The total nitrogen of the beef extracts on the water-free and fat-free basis averages 11.82 per cent, that of the yeast extracts averages 7.44 per cent. The amino nitrogen figures for the beef preparations are nearly double those of the yeast extracts.

(4) Although the water-soluble nitrogen of beef, which constitutes 25 per cent of the total nitrogen, consists of approximately two-thirds protein and one-third amino nitrogen, the samples of beef extracts analyzed average 72 per cent of amino nitrogen and 28 per cent of protein nitrogen.

(5) The general appearance and odor of the two varieties of extracts are very similar. As a food both are extremely limited in value. The beef extracts contain more of the nitrogenous extractives than the yeast preparations, otherwise their general composition is much the same.

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